Abstract

The present thesis deals with the experimental and numerical study of natural convection in a horizontal cavity containing air and condensable vapour. The presence of vapour in the system can enhance (suppress) natural convection if the molecular weight of the vapour is lower (higher) than air. The numerical solution of the problem is obtained for two different models. In one case we assume that the vapour is saturated everywhere and hence the species conservation equation is not used. This is called the saturation model. In the other case the vapour is allowed to be supersaturated and hence the double–diffusion phenomenon has a role to play. This is called the double–diffusive model. The set of equations governing the conservation of mass, momentum, energy and species is solved using the SIMPLER algorithm. Three fluids whose vapour is considered are ethyl alcohol, butyl alcohol and water. The numerical simulation predicts the conditions under which natural convection is suppressed when a vapour with molecular weight greater than that of air is used. We find that the results obtained from the two dimensional numerical simulation are quite different from the previous work which was based on one–dimensional model (Srinivasan, 1992). The present numerical simulation also predicts the possibility of "partial convection" in which natural convection occurs in the upper half of the cavity but there is no motion in the lower half of the cavity.

The results from numerical simulation are compared with experimental observations. The saturation model shows better agreement with some experimental observations than the double–diffusive model. Our experimental observation also confirms the existence of "partial convection" in the cavity. It is shown that the suppression of convection need not reduce

heat transfer in comparison to air alone in the cavity This result was not anticipated by Srinivasan (1992) who used a one–dimensional model and assumed that the temperature difference between the top and bottom plate is small It is also found that the spacing between the plates must be large in order to ensure that the total heat transfer is reduced when convection is suppressed The present work highlights the latent heat released during condensation We find that it has a profound impact on the temperature and density profiles

The results obtained in the present work can be used to design horizontal solar collectors in which convection needs to be suppressed by density stratification In the case of cooling of electronic equipments, water vapour–air mixture can be used to enhance the heat transfer